PRODUCTIVITY OF WILD AND CAPTIVE NENE POPULATIONS

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INTRODUCTION

Considerable information concerning the breeding biology of Nene (Branta sandvicensis) has been generated by the intensive efforts of aviculturalists to propagate the species in captivity (Kear and Berger 1980). Yet little is known of the Nene's breeding behavior in the wild because few field investigations have been conducted or their results published. Wild populations are small and usually scattered throughout remote, rugged areas during the nesting season, making them difficult to study.

My efforts since 1977 have focused on assessing the productivity of wild pairs in order to identify management actions which might aid the conservation of this endangered species within and adjacent to Hawaii Volcanoes and Haleakala National Parks.

There are many factors which may affect the production of viable offspring. Some characteristics of individuals which are pertinent to determining their reproductive potential include: age, physical condition and health, ability to attract and maintain a stable bond with a productive

mate, quantity and viability of gametes, normalcy of endocrinological functions, ability to maximally channel energy resources into reproductive activity, ability to recognize and exploit habitat which is optimal for breeding, level of experience and skill in carrying out nesting and rearing activities, ability to avoid or defend against predators and ability to cope with adverse environmental conditions.

Productivity at the population level can be assessed when there is knowledge of the following: sex ratio within the population, age structure of the population, ages at which reproduction is physiologically possible and ages during which fecundity is greatest, mean clutch size, fertility of eggs, success rate of clutches, survival rate of goslings and frequency at which second nests are attempted.

At this time information on only some of these factors which affect Nene productivity can be presented. Attention is given here to sex ratio, proportion of breeders to nonbreeders in the population, the frequency of breeding attempts per pair, clutch size, fertility of eggs, hatchability of eggs, clutch success, factors responsible for clutch failure and the rate of gosling mortality. Breeding characteristics of wild populations are compared with those of captive stocks whenever appropriate.

METHODS

Principal study areas on Hawaii and Maui are shown in Figures 1 and 2. Field work commenced in late 1977 on Hawaii and in early 1979 on Maui and continued sporadically through 1981.

Nonsystematic surveys for birds and nests were made on foot during

November - April in areas which were known or thought to be utilized by breeding geese. Field effort, varying with the number and capability of available assistants, was uneven from year to year and from one area to another. A trained Brittany spaniel was very useful in locating pairs, nests and broods primarily during 1979 - 1981 on Hawaii and in 1981 on Maui.

Whenever geese were sighted their breeding status was recorded if it could be determined. Females were closely examined for signs of being gravid (indicated by a swollen abdomen) or of having an incubation patch (missing or ruffled feathers on the upper abdomen). The behavior of lone ganders was observed for signs of nest defense. If females showed no evidence of having bred during December - April they were assumed not to have nested that season. Unfortunately, many pairs were seen only once or twice during the entire breeding season and it is possible that some breeding attempts went undetected.

Nests were visited about once a week whenever possible after being initially located. Broods were especially difficult to monitor for gosling mortality and many pairs with young were not seen after discovery. Precautions were taken to avoid unnecessary disturbance to nesting pairs and broods.

RESULTS

Areas where nesting activity was observed are shown in Figures 3 and 4. The ratio of males to females in captivity is approximately 1:1 at

hatching. However, in the wild the mortality rate of females appears to be slightly higher than that of males, since on Hawaii adult males were 8% more abundant than females (Table 1). A similar excess of males was found on Maui, as well.

During the nesting season (late October - early April) most adults were paired. Unpaired females were seldom observed, but bachelor males were often seen singly, together in loose congregations of 2 - 5 individuals (especially at Paliku, Maui) or occasionally with breeding pairs.

Although Nene generally remain paired to the same mate for life, pair bonds which formed between siblings tended to persist only until new mates became available. A remarkable association of 2 males and a female has nested during the past 2 breeding seasons near HALE Headquarters, but the trio may be dissolving as 1 of the males appears finally to be pairing off with another female.

The proportion of paired birds in the Hawaii population decreased from 91% in 1978 to 76% in 1981. This decreasing ratio of paired to unpaired geese may be related to the decline of the total population. The number of birds known from all 3 Hawaii study areas dropped from 112 in 1978 to 34 in 1981 as a result of the virtual extinction of the Mauna Loa (Keauhou) population. Populations around Kilauea Crater and on the lowland slopes of Kilauea may have increased slightly in size. Field effort on Maui from 1979 to 1981 was too uneven to determine a clear population trend, but it appears that the population is not increasing.

The proportion of pairs which attempted to breed increased during the study. On Hawaii only 47% of the pairs encountered in the field attempted to nest in 1978 while 69% bred in 1981. Overall, 57% of the wild pairs seen

during the 4-year period were known to have bred (Table 1). Similarly, 59% of all available captive pairs and free-flying volunteers attempted to nest in HAVO pens from 1975 to 1981 (Table 2). At HALE, however, all pairs which have been available for nesting since 1973 have bred. Most wild pairs (75%) which bred on Hawaii did so in only 1 of the 4 years while 21% bred in 2 years and only 4% bred in 3 years (Table 3). No pairs bred in all 4 years.

Of the 67 breeding attempts which were observed in the wild on Hawaii during 1978 - 1981, only 2 resulted in fledglings (Table 4). Most females that were gravid were known to have laid eggs and initiated incubation, but only 37% were successful in hatching eggs.

It was possible to determine the success or failure of 70 active and inactive wild nests in hatching at least 1 egg (Table 5). Overall clutch success was 44% with virtually no difference between success rates for Hawaii and Maui populations.

The success rate of clutches laid in captivity was 79% at HAVO but only 36% at HALE (Table 6).

The most important factor responsible for clutch failure in the wild was predation by mongooses (Herpestes auropunctatus) on eggs (62%) and incubating females (10%), as shown in Table 7. Abandonment, storms, embryo mortality, accidental egg breakage by the female and other factors accounted for the remaining 28% of the clutch failures.

In NPS breeding pens only 12% of all clutch failures were attributable to egg predation (Table 8). The most serious causes of clutch failure in pens were embryo mortality (55%) and infertility (32%).

The mean clutch size for wild pairs on Hawaii and Maui was 3.1 (Table 9).

In NPS pens clutches averaged 4.0 eggs. At the state breeding center at Pohakuloa mean clutch size averaged 4.3 (Kear and Berger 1980).

Fertility of eggs in the wild (83%) was as high or higher than that of eggs laid in captivity (Table 9). Hatchability of wild eggs (85%) was the same or exceeded that of captive-laid eggs.

Gosling mortality approached 100% in the wild, was 34% in NPS pens and was only 9% at Pohakuloa and 15% at Slimbridge (Table 9). From 67 breeding attempts on Hawaii only 4 fledglings were produced in 4 years. On Maui 15 goslings were known to have fledged during 1979 - 1981. Out of 72 clutches laid in NPS pens 76 goslings fledged, 19 from HALE and 57 from HAVO.

Nene renest readily in captivity, especially when the first clutch is removed and the nest is destroyed. Using this method of propagation as many as 4 clutches have been laid in a single season by some females at Pohakuloa (Lee 1978). Even when clutches were not removed and the goose was allowed to incubate her first clutch to term some pairs renested. A female at HAVO renested about the time that young from her first clutch were fledging.

The frequency of renesting in the wild appears to be less than in captivity. On each island there were 3 renest attempts, comprising 9% of the total number of active nests located.

DISCUSSION

The productivity of wild Nene populations was extremely low because many pairs did not attempt to nest while most of those that did breed fail-

ed to hatch any of their eggs and even fewer produced young which fledged. There are many physiological and environmental factors which may have affected whether or not pairs attempted to breed. The dry weather which prevailed in the breeding areas throughout all breeding seasons during the study possibly had a direct or indirect negative impact not only on the ability of birds to breed but also on the productivity of those that did nest. However, this hypothesis cannot be tested with my data.

An approach which is actively being investigated is to examine the endocrinological events associated with breeding and nonbreeding captive pairs to determine some of the physiological parameters of Nene reproduction. Results of this study should soon be available for analysis.

Clearly, the most important factor responsible for clutch failure in the wild population was predation by mongooses on eggs and incubating females. Nest abandonment, storms, embryo mortality and accidental egg breakage were relatively minor adverse factors when the fate of the entire clutch is considered. However, many clutches which were ultimately successful in hatching at least 1 egg were depleted by embryo mortality and infertility.

The factors responsible for the extremely high mortality rate of goslings in the wild were not determined. Circumstantial evidence from monitoring the growth and survival of HAVO captive young suggests that nutrition may have been inadequate in many instances. Predation perhaps was important in the wild, too, but it has not been a factor in HAVO pens where mortality was fairly high (34%). No pathogens were implicated in any gosling deaths, but this aspect has not been extensively investigated.

Until further research provides other insights the best that resource managers can do to enhance the productivity of wild Nene is to reduce pre-

datory pressures being exerted on eggs and females by mongooses. Increasing the availability of suitable foods may be another measure which might promote better gosling survival.

ACKNOWLEDGEMENTS

I thank Katy Belt, Bonnie Burkhart, Garvin Clarke, Jeffrey Harbison, Sarah Hinckley, Howard Hoshide, Kathleen Hunt, Susan Inkel, Leslie Jensen, Veronica Marrotte, Arthur Medeiros, Katherine Savage and Joseph Van Horn for valuable assistance in the field. Nelson Santos, Meyer Ueoka and Edwin Andrade of Hawaii Division of Wildlife were very helpful in sharing their field observations and insights.

Research was supported by the National Park Service under contract CX8000-8-0005.

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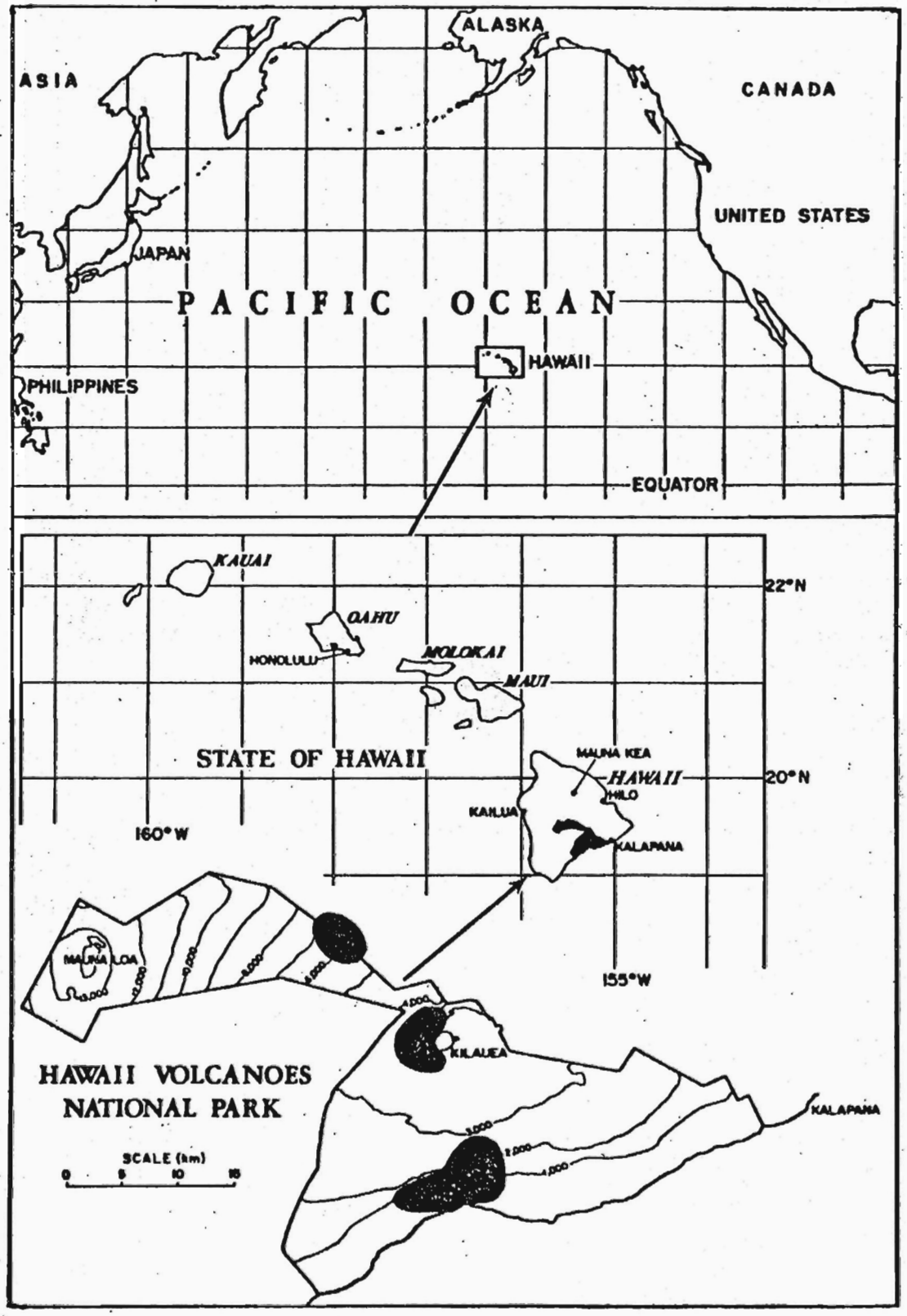

FIGURE 1. LOCATION OF HAWAII VOLCANOES NATIONAL PARK AND MAJOR STUDY AREAS.

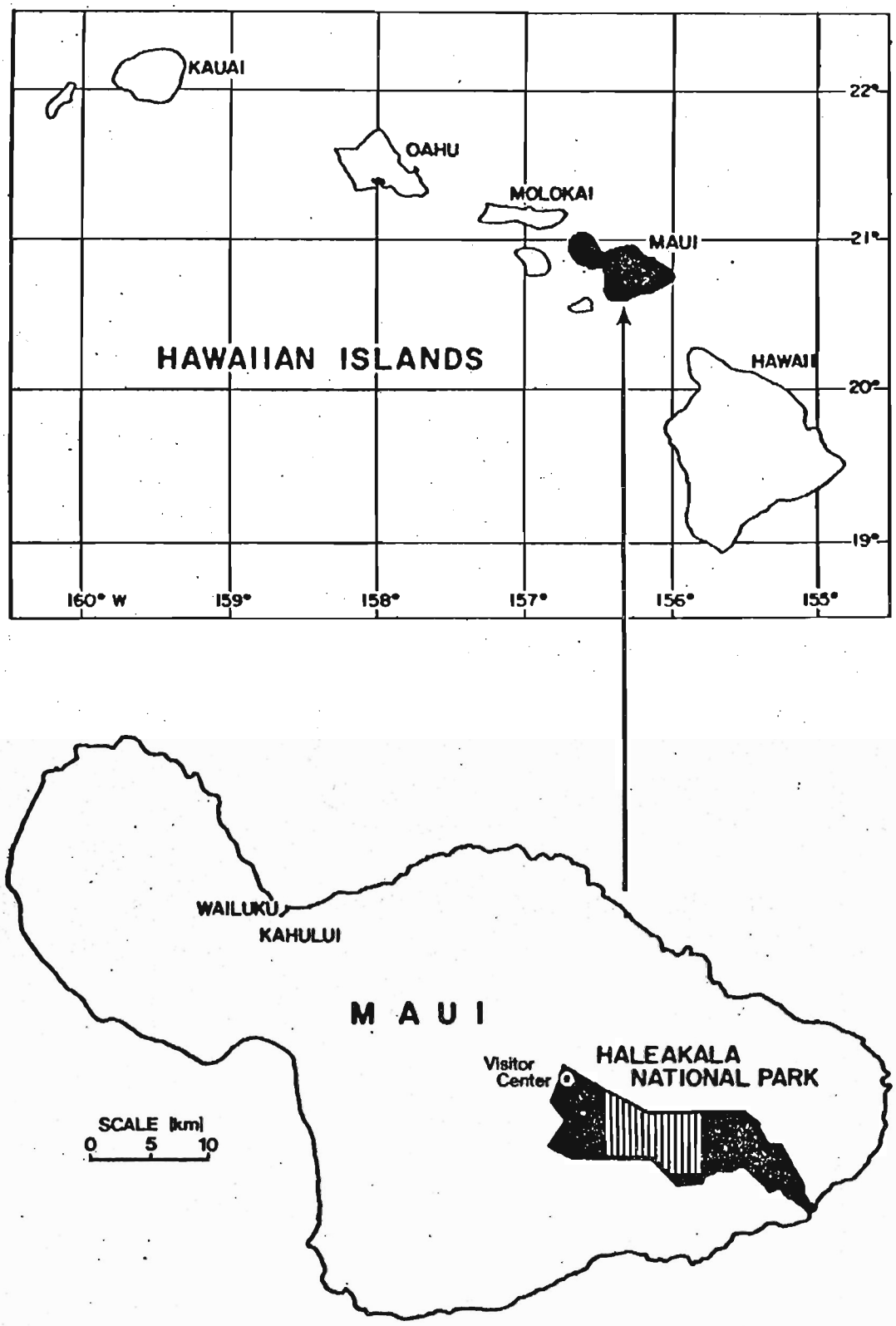

FIGURE 2. LOCATION OF HALEAKALA NATIONAL PARK AND MAJOR STUDY AREAS.

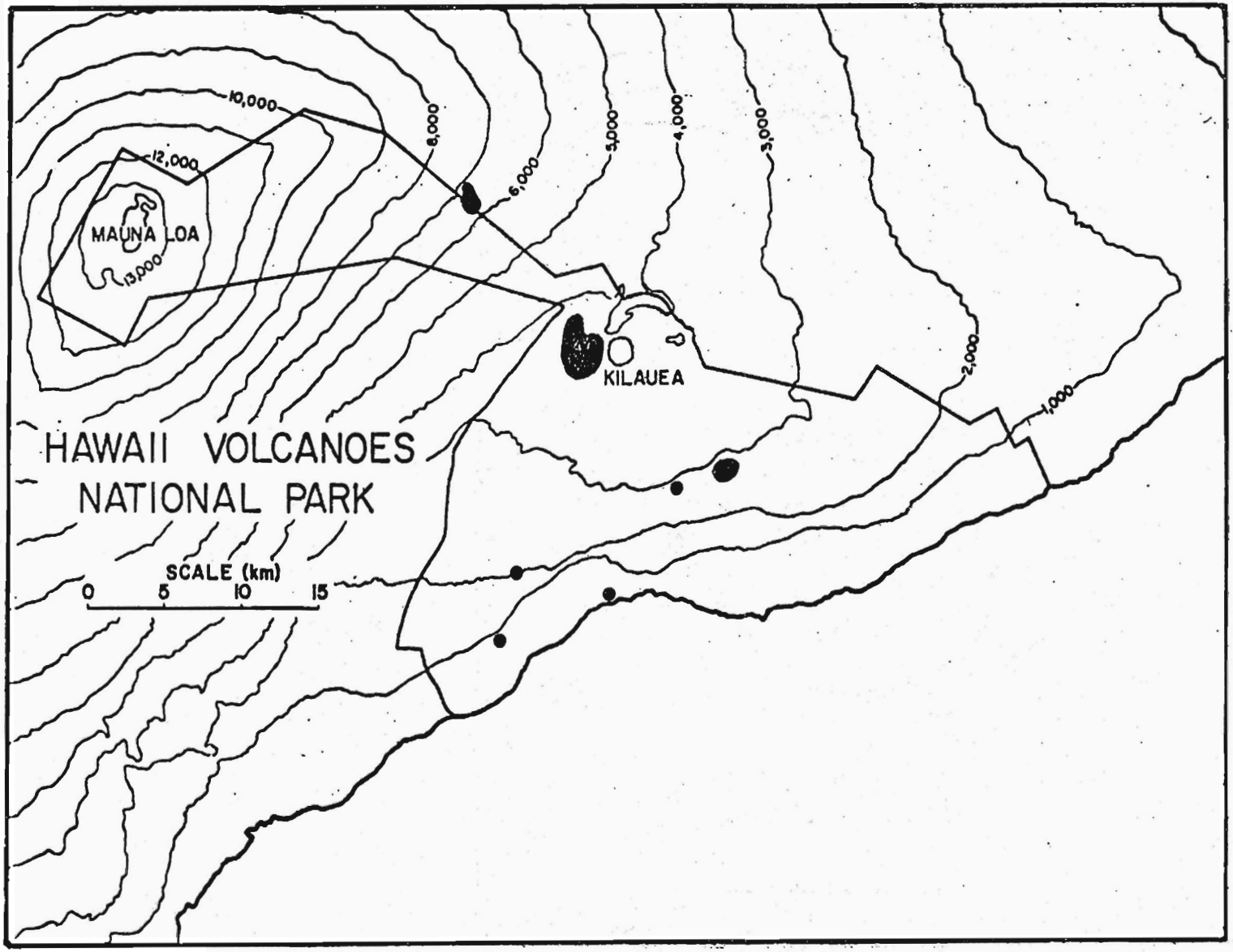

FIGURE 3. NESTING AREAS OF WILD PAIRS IN AND ADJACENT TO HAWAII VOLCANOES NATIONAL PARK.

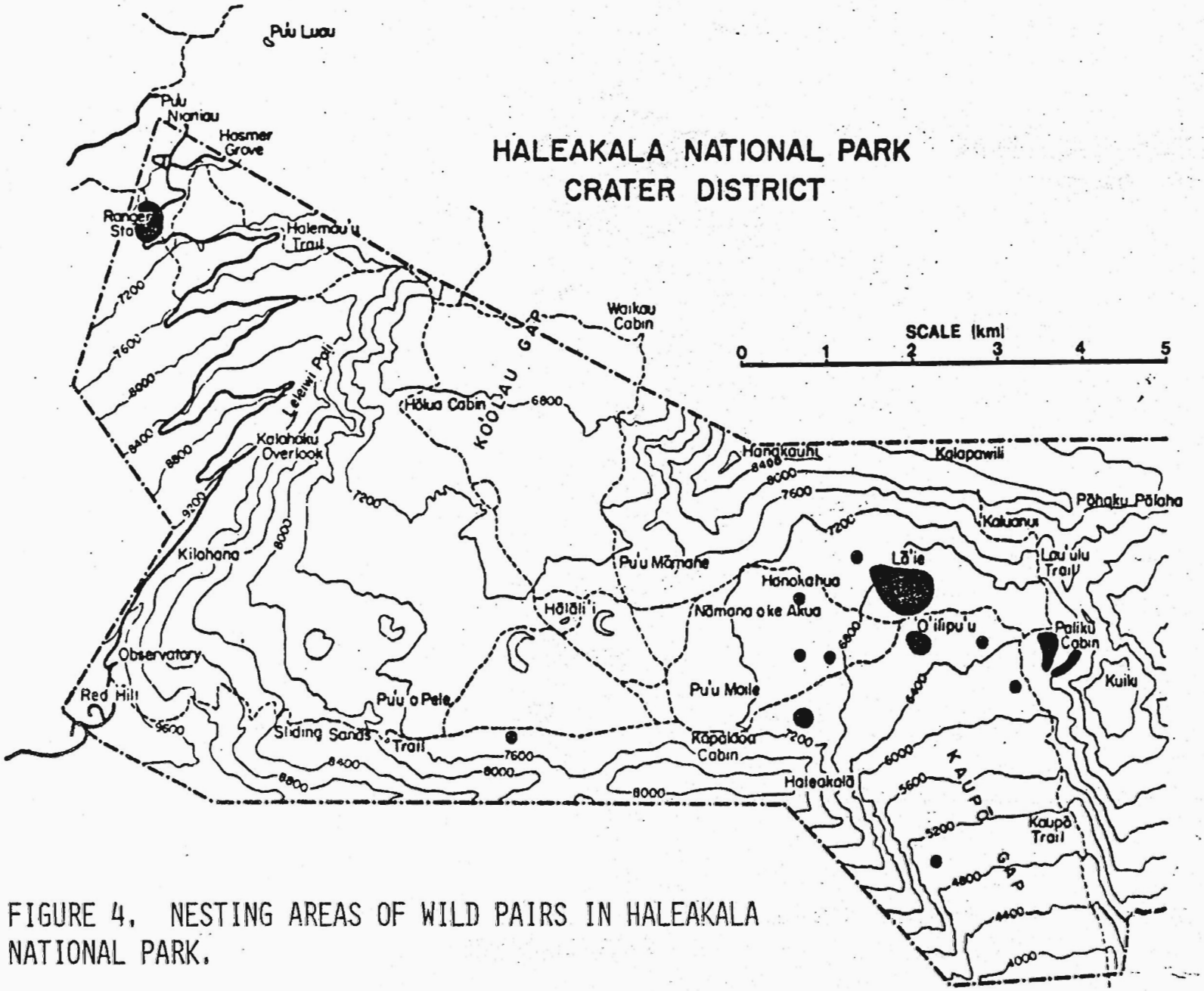

FIGURE 4. NESTING AREAS OF WILD PAIRS IN HALEAKALA NATIONAL PARK.

TABLE 1

WILD NENE BREEDING ACTIVITY DURING 1978-1981 ON HAWAII

MALES	FEMALES
106 (54 %)	90 (46 %)

YEAR	PAIRS	UNPAIRED INDIVIDUALS	TOTAL INDIVIDUALS
1978	51	10	112
1979	35	12	82
1980	19	14	52
1981	13	8	34

YEAR	PAIRS WHICH ATTEMPTED TO BREED	PAIRS WHICH FAILED TO BREED
1978	24	27
1979	22	13
1980	12	7
1981	9	4
	67 (57 %)	51 (43 %)

TABLE 2

BREEDING ACTIVITY OF CAPTIVE AND FREE-FLYING NENE IN NPS PENS

YEAR	HAVO PAIRS		HALE PAIRS	
	BREEDING	NO BREEDING	BREEDING	NO BREEDING
1973	---	---	2	0
1974	---	---	2	0
1975	1	0	2	0
1976	5	1	2	0
1977	6	3	3	0
1978	6	3	3	0
1979	4	4	3	0
1980	5	7	4	0
1981	5	4	3	0
	32 (59 %)	22 (41 %)	24 (100 %)	0

TABLE 3

FREQUENCY OF BREEDING ATTEMPTS DURING 1978-1981 ON HAWAII

NUMBER OF SEASONS	NUMBER OF BREEDING PAIRS
1	39
2	11
3	2
4	0

TABLE 4

PRODUCTIVITY OF BREEDING PAIRS DURING 1978-1981 ON HAWAII

	1978	1979	1980	1981
FEMALES THAT WERE GRAVID	24	22	12	9
FEMALES THAT LAID EGGS/INCUBATED	21	19	6	7
PAIRS THAT HATCHED EGGS	12	2	4	7
PAIRS THAT FLEDGED YOUNG	1	0	0	1
FLEDGLINGS PRODUCED	1	0	0	3

TABLE 5

SUCCESS OF WILD CLUTCHES DURING 1978-1981

	TOTAL	HAWAII	MAUI
TOTAL ACTIVE AND INACTIVE NESTS	80	40	40
FATE OF CLUTCH UNDETERMINED	10	3	7
CLUTCH SUCCESSFUL (AT LEAST 1 EGG HATCHED)	31 (44 %)	16 (43 %)	15 (45 %)
CLUTCH UNSUCCESSFUL (NO EGGS HATCHED)	39 (56 %)	21 (57 %)	18 (55 %)

TABLE 6

CLUTCH SUCCESS OF PEN-BREEDING PAIRS

	TOTAL	HAVO 1975-81	HALE 1973-81
CAPTIVE PAIRS			
TOTAL CLUTCHES	62	30	32
CLUTCH SUCCESSFUL (AT LEAST 1 EGG HATCHED)	37 (60 %)	25 (83 %)	12 (38 %)
CLUTCH UNSUCCESSFUL (NO EGGS HATCHED)	25 (40 %)	5 (17 %)	20 (62 %)
FREE-FLYING VOLUNTARY PEN-BREEDERS			
TOTAL CLUTCHES	10	9	1
CLUTCH SUCCESSFUL	6 (60 %)	6 (67 %)	0
CLUTCH UNSUCCESSFUL	4 (40 %)	3 (33 %)	1

TABLE 7

FACTORS RESPONSIBLE FOR CLUTCH FAILURE

	TOTAL	HAWAII	MAUI
UNSUCCESSFUL CLUTCHES	39	21	18
FEMALE KILLED BY PREDATOR OR DISAPPEARED	4 (10 %)	4 (19 %)	0
CLUTCH DESTROYED BY PREDATOR	24 (62 %)	13 (62 %)	11 (61 %)
CLUTCH DESTROYED BY STORM	2 (5 %)	0	2 (11 %)
CLUTCH DESTROYED BY ACCIDENTAL EGG BREAKAGE	2 (5 %)	0	2 (11 %)
CLUTCH ABANDONED	4 (10 %)	2 (10 %)	2 (11 %)
EMBRYO MORTALITY	2 (5 %)	1 (5 %)	1 (6 %)
UNKNOWN FACTORS	1 (3 %)	1 (5 %)	0

TABLE 8

FACTORS RESPONSIBLE FOR CLUTCH FAILURE IN NPS BREEDING PENS

	TOTAL	HAVO 1975-81	HALE 1973-81
CAPTIVE PAIRS			
UNSUCCESSFUL CLUTCHES	25	5	20
EMBRYO MORTALITY	13 (52 %)	3 (60 %)	10 (50 %)
CLUTCH INFERTILE	8 (32 %)	1 (20 %)	7 (35 %)
CLUTCH DESTROYED BY PREDATOR	3 (12 %)	1 (20 %)	2 (10 %)
CLUTCH ABANDONED (FERTILITY UNDETERMINED)	1 (4 %)	0	1 (5 %)
FREE-FLYING VOLUNTARY PEN-BREEDERS			
UNSUCCESSFUL CLUTCHES	4	3	1
EMBRYO MORTALITY	3 (75 %)	3	0
FEMALE ACCIDENTALLY KILLED	1	0	1

TABLE 9

CLUTCH SIZE, FERTILITY, HATCHABILITY AND GOSLING MORTALITY IN WILD POPULATIONS AND CAPTIVE BREEDING STOCKS

	CLUTCH SIZE	FERTILITY	HATCHABILITY	GOSLING MORTALITY
WILD	3.1	83 %	85 %	96 %
HAWAII	3.1	81 %	87 %	100 %
MAUI	3.1	87 %	83 %	92 %
NPS	4.0	66 %	75 %	34 %
HAVO	3.8	84 %	84 %	34 %
HALE	4.3	47 %	57 %	34 %
POHAKULOA	4.2	81 %	59 %	9 %
SLIMBRIDGE	4.3	68 %	53 %	15 %

Clutch size calculation for Slimbridge excludes clutches of only 1 or 2 eggs.

Pohakuloa fertility is calculated only for 1961-1972; prior to this period fertility was less than 50%. Similarly, Slimbridge fertility is calculated only for 1967-1972.

Wild egg hatchability is calculated only for eggs which were known or assumed to have been incubated to term. Pohakuloa hatchability is calculated for 1954-1972. Slimbridge hatchability is calculated for 1952-1972.

Wild gosling mortality excludes fledglings which had no nest or brood histories and goslings whose fates were undetermined. Pohakuloa gosling mortality covers only the first 2 weeks after hatching during 1954-1972. Slimbridge gosling mortality is for 1952-1972.

All calculations for Pohakuloa and Slimbridge use data presented in Kear and Berger (1980).